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(54) **DAMPING FORCE VARIABLE VALVE
ASSEMBLY AND DAMPING FORCE
VARIABLE SHOCK ABSORBER HAVING
THE SAME**

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(52) **U.S. Cl.**

CPC **F16F 9/512** (2013.01); **Y10T 137/87096**
(2015.04)

(58) **Field of Classification Search**

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USPC 188/314, 322.13

See application file for complete search history.

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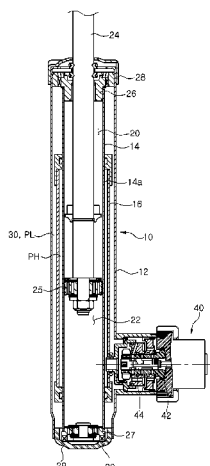
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(57) **ABSTRACT**

Provided are a damping force variable valve assembly with a low-speed control valve capable of controlling an ultra-low flow rate and a low flow rate when a damping force variable valve operates in a soft mode, and a damping force variable shock absorber including the damping force variable valve assembly. The damping force variable valve assembly, which is installed in a damping force variable shock absorber for adjustment of a damping force of the shock absorber, includes: a solenoid; a spool which is movable by the magnetic force of the solenoid; a spool guide which surrounds the spool; a main valve which is installed in a main passage formed in a valve body installed in the spool guide; a back pressure chamber which is provided in the rear of the main valve; a chamber forming body which forms the back pressure chamber.

7 Claims, 5 Drawing Sheets



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Fig. 1

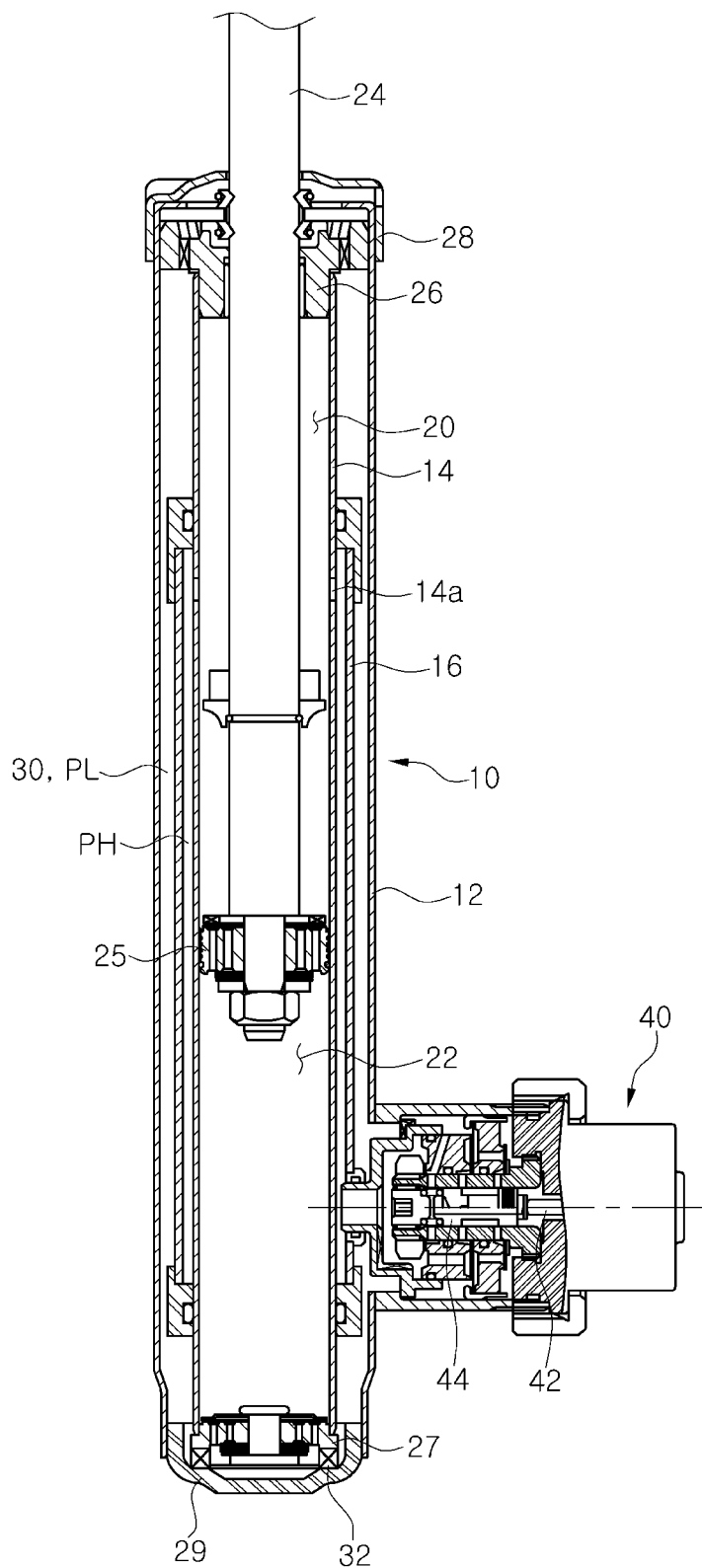


Fig. 2

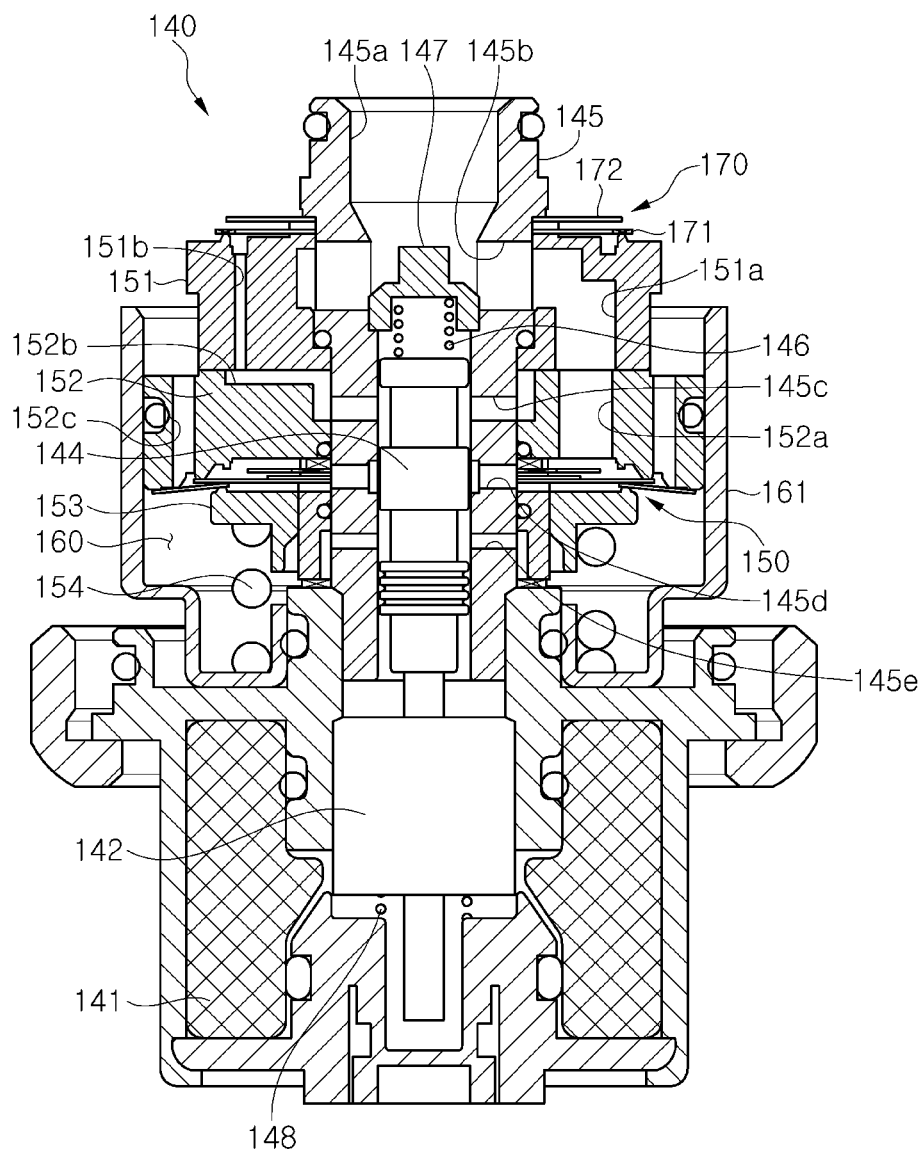


Fig. 3

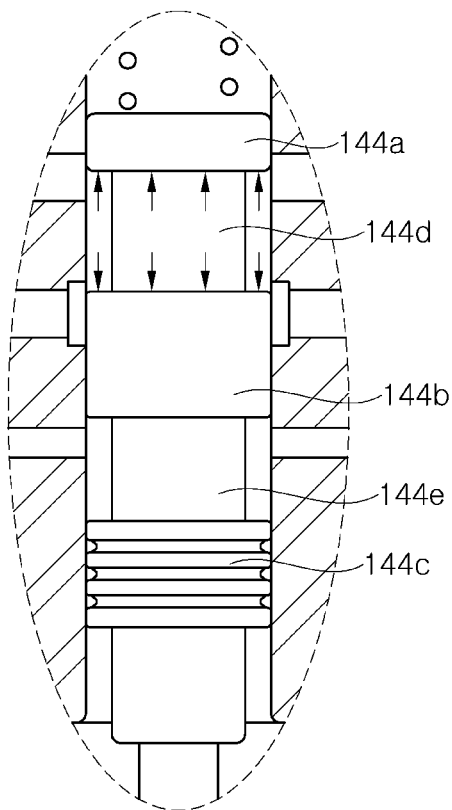


Fig. 4

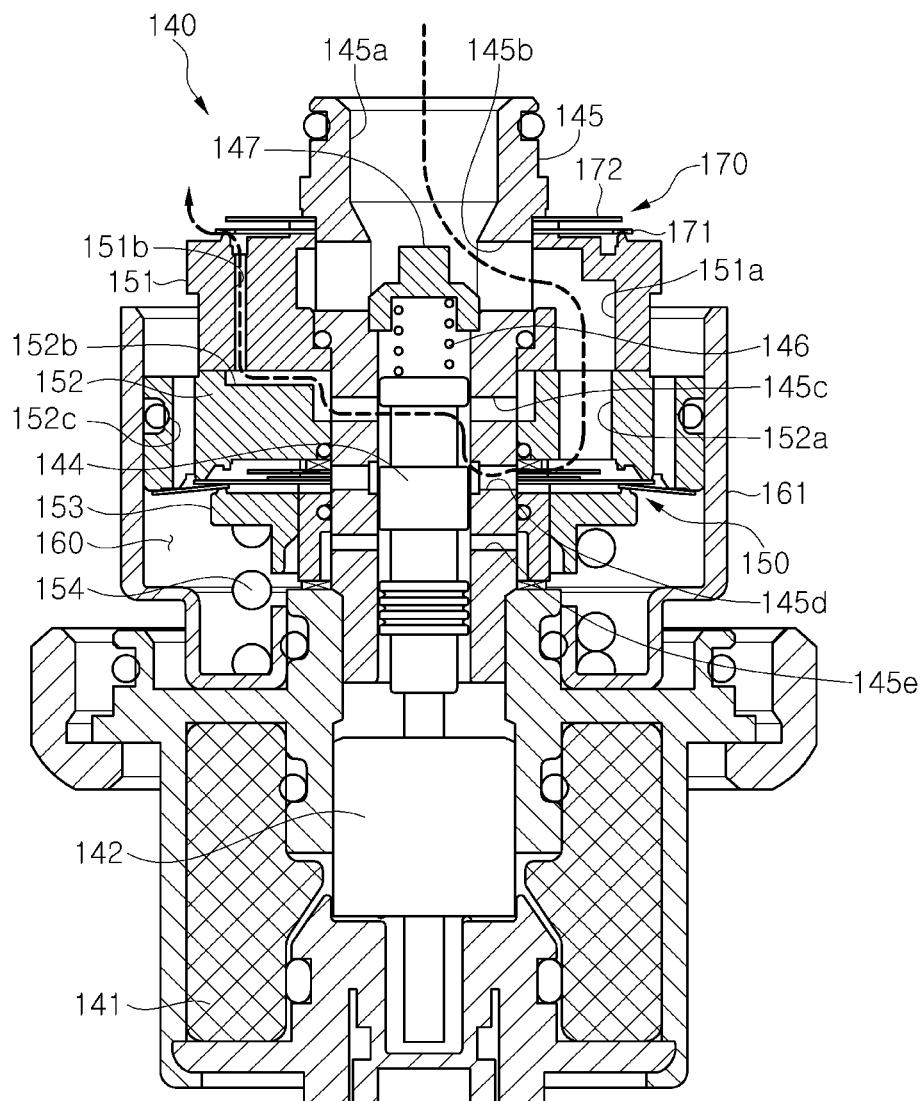
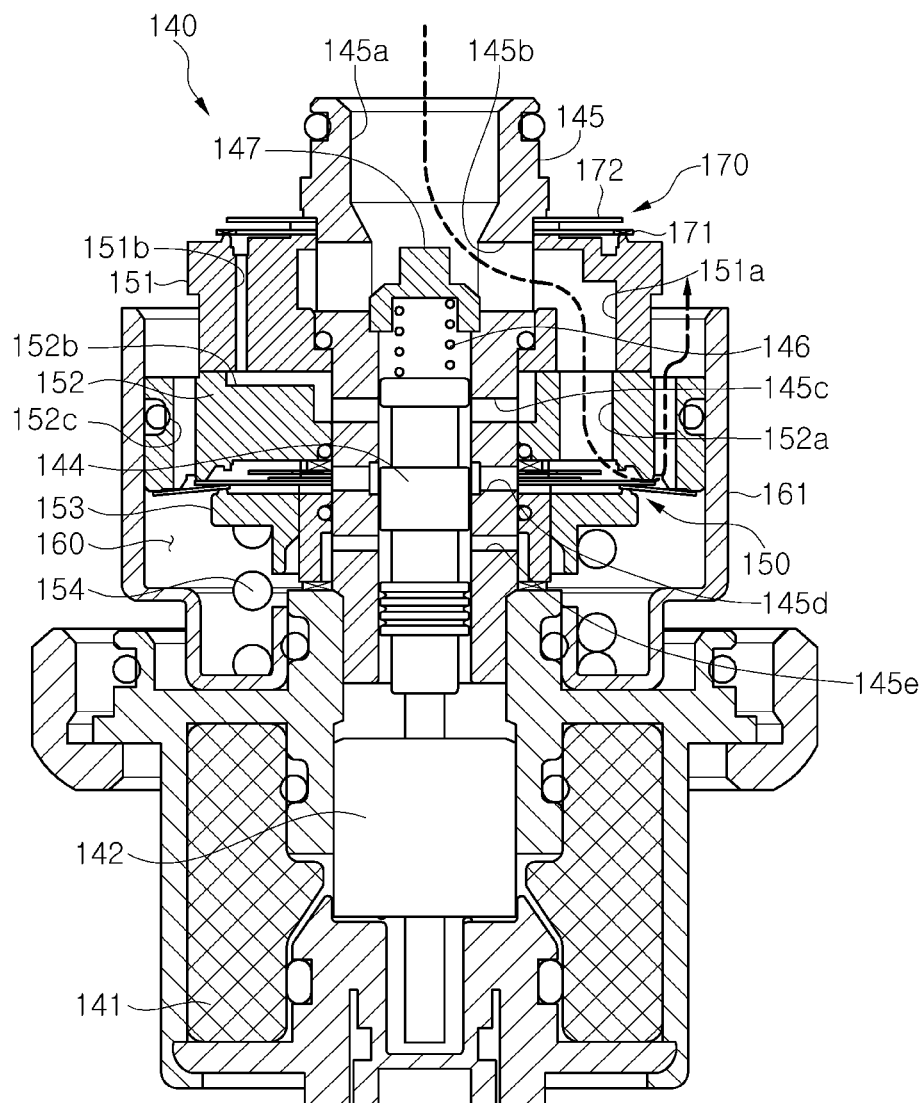


Fig. 5



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DAMPING FORCE VARIABLE VALVE ASSEMBLY AND DAMPING FORCE VARIABLE SHOCK ABSORBER HAVING THE SAME

CROSS-REFERENCE(S) TO RELATED APPLICATION

This application claims priority of Korean Patent Application No. 10-2013-0030691, filed on Mar. 22, 2013, in the Korean Intellectual Property Office, the contents of which are incorporated herein by reference in its entirety.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a damping force variable valve assembly installed in a damping force variable shock absorber, and more particularly, to a damping force variable valve assembly with a low-speed control valve capable of controlling an ultra-low flow rate and a low flow rate when a damping force variable valve operates in a soft mode, and a damping force variable shock absorber including the damping force variable valve assembly.

2. Description of the Related Art

Generally, a shock absorber is installed in means of transportation such as an automobile or the like, and improves a ride comfort by absorbing and damping a vibration or shock from a road surface on the drive.

Such a shock absorber includes a cylinder and a piston rod installed to be compressible and extendable within the cylinder. The cylinder and the piston rod are installed in a vehicle body, wheels, or axles.

A shock absorber, a damping force of which is set to be low, can improve a ride comfort by absorbing a vibration caused by uneven road surface on the drive. On the contrary, a shock absorber, a damping force of which is set to be high, can improve a steering stability by suppressing a change in a posture of a vehicle body. Therefore, in the conventional vehicles, different damping force characteristics are set to shock absorbers according to the purpose of use of the vehicles.

Meanwhile, a damping force variable shock absorber has recently been developed which is mounted with a damping force variable valve at one side of the shock absorber so as to appropriately adjust a damping force characteristic, and can appropriately adjust a damping force characteristic to improve a ride comfort or a steering stability according to a road surface, a drive status, and the like.

FIG. 1 is a cross-sectional view illustrating an example of a conventional damping force variable shock absorber. The conventional damping force variable shock absorber 10 includes a base shell 12 and an inner tube 14 which is movably installed inside the base shell 12 and in which a piston rod 24 is movably installed in a length direction. A rod guide 26 and a body valve 27 are installed in an upper portion and a lower portion of the inner tube 14 and the base shell 12, respectively. In addition, a piston valve 25 is connected to one end of the piston rod 24 within the inner tube 14, and the piston valve 25 partitions an inner space of the inner tube 14 into a rebound chamber 20 and a compression chamber 22. A top cap 28 and a base cap 29 are installed in an upper portion and a lower portion of the base shell 12, respectively.

A reservoir chamber 30 is formed between the inner tube 14 and the base shell 12 to compensate for a change in a volume of the inner tube 14 according to a reciprocating

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motion of the piston rod 24. A flow of a working fluid between the reservoir chamber 30 and the compression chamber 22 is controlled by the body valve 27.

In addition, a separator tube 16 is installed inside the base shell 12. Due to the separator tube 16, the inside of the base shell 12 is partitioned into a high pressure chamber PH connected to the rebound chamber 20, and a low pressure chamber PL serving as the reservoir chamber 30.

The high pressure chamber PH is connected to the rebound chamber 20 through an inner hole 14a of the inner tube 14. On the other hand, the low pressure chamber PL is connected to the compression chamber 22 through a lower passage 32, which is formed between a body portion of the body valve 27 and the base shell 12 (or the base cap 29), and a passage formed in the body valve 27.

Meanwhile, the conventional shock absorber 10 includes a damping force variable valve assembly 40 mounted at one side of the base shell 12 so as to vary a damping force.

The damping force variable valve assembly 40 is provided with oil passages communicating with the high pressure chamber PH and the low pressure chamber PL connected to the base shell 12 and the separator tube 16, respectively. In addition, the damping force variable valve assembly 40 includes a spool 44 installed to be moved by a driving of a plunger 42. An inner passage communicating with the high pressure chamber PH and the low pressure chamber PL is varied by movement of the spool 44, and a damping force of the shock absorber is varied accordingly. The plunger 42 is configured to move in a horizontal direction, when viewed in FIG. 1, due to a magnetic force generated when an electric current flows through a solenoid.

In the conventional damping force variable valve assembly, for example, when the plunger 42 moves left, the spool 44 closes the passage to generate a high damping force (hard mode). On the contrary, when the plunger 42 moves right, the spool 44 opens the passage to generate a low damping force (soft mode).

In the technical field to which the invention pertains, many efforts have been made to provide a shock absorber having a good damping force variable characteristic by improving the performance of a damping force variable valve assembly. For example, Korean Patent Application Publication Nos. 10-2010-0023074 and 10-2010-0007187 disclose techniques of damping force variable valve assemblies recently developed for a shock absorber.

However, in spite of many efforts to improve the performance of the damping force variable valve assembly, the conventional shock absorber has a poor damping force characteristic in a section where a moving speed of a working fluid is low.

In the damping force variable valve assembly 40, when a moving speed of a working fluid is high, that is, when a flow rate is high, a resistance is determined by a sagging amount of main disk valves stacked in a valve assembly.

However, when an input (that is, shock) from a road surface is small and thus a moving speed of a working fluid is low or ultra-low, a flow rate of a working fluid flowing in a shock absorber is so extremely low that a resistance by a fixed orifice is not formed. Therefore, a damping force is not generated in a low-speed section, and a small vibration transferred from a road surface is not reduced.

SUMMARY OF THE INVENTION

The present invention has been made in an effort to solve the above problems and is directed to provide a damping force variable valve assembly having a valve structure for a

low flow rate control, which is capable of generating a damping force even in an ultra-low or low flow rate section of a working fluid when a damping force variable valve operates in a soft mode, and a damping force variable shock absorber including the damping force variable valve assembly.

According to an aspect of the present invention, a damping force variable valve assembly, which is installed in a damping force variable shock absorber for adjustment of a damping force of the shock absorber, includes: a solenoid which generates a magnetic force when an electric current is applied thereto; a spool which is movable by the magnetic force of the solenoid; a spool guide which surrounds the spool to guide a movement of the spool; a valve body which is installed in the spool guide; a main valve which is installed in a main passage formed in the valve body, and generates a damping force; a back pressure chamber which is provided to have a back pressure to pressurize the main valve from the rear of the main valve; a chamber forming body which is installed outside the valve body to form the back pressure chamber; and a low-speed control valve which is installed in a low-speed passage formed in the valve body, and generates a damping force, wherein the damping force of the shock absorber is variable between a hard mode in which the back pressure of the back pressure chamber is increased and a soft mode in which the back pressure of the back pressure chamber is decreased, when an inner passage within the damping force variable valve assembly is changed by interaction of the spool and the spool guide, and the low-speed control valve generates the damping force when a flow rate of a working fluid is low in the soft mode.

The valve body may be formed by sintering, and the chamber forming body may be formed by press processing.

The spool may be provided by alternately forming large-diameter portions and small-diameter portions, and the large-diameter portions may be formed on both sides of the small-diameter portion so that a pressure of a working fluid passing through the small-diameter portion is equally applied to the large-diameter portions formed on both side of the small-diameter portion.

A stepped portion coming into contact with the low-speed control valve may be formed on an outer peripheral surface of the inlet port of the spool guide, and the low-speed control valve may be assembled by interposing between the stepped portion and the valve body fitted into the spool.

The main passage and the low-speed passage may form separate passages so that the main valve and the low-speed control valve are installed in parallel, and a working fluid supplied to the main valve may not pass through the low-speed control valve, and a working fluid supplied to the low-speed control valve may not pass through the main valve.

According to another aspect of the present invention, a damping force variable shock absorber for adjusting a damping force of the shock absorber, includes: a base shell in which a damping force variable valve assembly is attached to an outside thereof; an inner tube which is installed inside the base shell and in which a piston rod is installed movably in a length direction; a piston valve which is connected to one end of the piston rod such that an inner space of the inner tube is partitioned into a rebound chamber and a compression chamber; and a separator tube which partitions a space between the base shell and the inner tube into a low pressure chamber and a high pressure chamber. The damping force variable valve assembly may include: a spool which is movable by a magnetic force of a solenoid; a spool guide which surrounds the spool to guide a move-

ment of the spool; a main valve which is installed to cover a main passage formed in a valve body installed in the spool guide and generates a damping force; and a low-speed control valve which is installed to cover a low-speed passage formed in the valve body and generates a damping force. The damping force of the shock absorber may be variable between a hard mode in which a back pressure of a back pressure chamber installed at the rear of the main valve is increased and a soft mode in which the back pressure of the back pressure chamber is decreased, as an inner passage within the damping force variable valve assembly is changed by interaction of the spool and the spool guide. The low-speed control valve may generate the damping force when a flow rate of a working fluid is low in the soft mode.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a cross-sectional view illustrating an example of a conventional damping force variable shock absorber.

FIG. 2 is a cross-sectional view of a damping force variable valve assembly with a low-speed control valve according to the present invention.

FIG. 3 is a partial enlarged cross-sectional view illustrating a spool of a damping force variable valve assembly with a low-speed control valve according to the present invention.

FIG. 4 is a view for explaining an operation state of the damping force variable valve assembly according to the present invention, when a flow rate of a working fluid is low in a soft mode.

FIG. 5 is a view for explaining an operation state of the damping force variable valve assembly according to the present invention, when a flow rate of a working fluid is medium or high in a soft mode.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

Hereinafter, a damping force variable valve assembly of a damping force variable shock absorber according to exemplary embodiments of the present invention will be described in detail with reference to the accompanying drawings. In the following description given with reference to FIGS. 2 to 5, like reference numerals as those of FIG. 1 are used to refer to like elements.

According to the present invention, the damping force variable valve assembly 140 is provided with oil passages communicating with a high pressure chamber PH and a low pressure chamber PL connected to a base shell 12 and a separator tube 16, respectively. Since a structure in which the damping force variable valve assembly 140 is connected to the base shell 12 and the separator tube 16 and communicates with the high pressure chamber PH and the low pressure chamber PL is similar to that of the related art illustrated in FIG. 1, a structure in which the damping force variable valve assembly is connected to a side of the shock absorber is not illustrated in FIGS. 2 to 5.

The damping force variable valve assembly 140 includes a spool 144 installed to be moved by a driving of a plunger 142. An inner passage of the damping force variable valve assembly which communicates with the high pressure chamber PH and the low pressure chamber PL is varied by movement of the spool 144, and a damping force of the shock absorber is varied accordingly.

The damping force variable valve assembly 140 includes a main valve 150 and a back pressure chamber 160 used for varying the damping force of the shock absorber. The back

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pressure chamber **160** is provided to have a back pressure to pressurize the main valve **150** from the rear of the main valve **150**.

The main valve **150** is installed to cover the main passage formed in a valve body from the rear of the valve body. On the other hand, the valve body is connected to the high pressure chamber PH of the above-described shock absorber through a spool guide **145** installed inside. The valve body is formed by sintering, but is not necessarily formed by a single sintered body. In the present embodiment, the valve body is provided with a first body **151** and a second body **152** formed by sintering. In addition, passages for performing various functions are formed in the first body **151** and the second body **152** constituting the valve body.

The spool guide **145** includes an inlet port **145a**, one or more first inlet passages **145b**, and first to third passages **145c**, **145d** and **145e**. The first inlet port **145a** is formed along a length direction such that a working fluid is introduced from the high pressure chamber PH. The one or more first inlet passages **145b** are formed along a width direction to communicate with the inlet port **145a**. The first to third passages **145c**, **145d** and **145e** are formed to block or permit the flow of the working fluid by interaction with the spool **144** as described below.

The first body **151** includes a second inlet passage **151a** formed to communicate with the first inlet passage **145b** of the spool guide **145**, and the second body **152** includes a third inlet passage **152a** formed to communicate with the second inlet passage **151a** of the first body **151**.

The inlet port **145a**, the first inlet passage **145b**, the second inlet passage **151a**, and the third inlet passage **152a** form the main passage such that the working fluid from the high pressure chamber PH can flow toward the main valve **150**.

On the other hand, in order to form the passage of the working fluid flowing toward a low-speed control valve **170** in a low-speed section, a first low-speed passage **152b** is formed in the second body **152**, and a second low-speed passage **151b** is formed in the first body **151**.

In addition, in order to form the passage of the working fluid moving toward the low pressure chamber PL through the main valve **150** in a medium/high-speed section, a medium/high-speed passage **152c** is formed in the second body **152**.

The back pressure chamber **160** is provided such that the pressure thereof is varied according to a driving of a solenoid **141** (that is, movement of the spool **144** due to the driving of the solenoid **141**). A change in the pressure inside the back pressure chamber **160**, that is, a change in the back pressure to the main valve **150**, causes the main valve **150** to vary a force against the fluid passing through the main passage, thereby providing a varied damping force to the shock absorber.

According to the present invention, a chamber forming body **161** for forming the back pressure chamber **160** may be formed by press processing. Since the chamber forming body **161** is formed as a pressed product, it is possible to reduce a total weight of the damping force variable valve assembly, reduce manufacturing cost and time of the valve body formed by sintering, and reduce time and effort necessary for manufacturing.

A main retainer **153** and a main spring **154** are disposed in the back pressure chamber **160** so as to pressurize disks of the main valve **150** toward the valve body, that is, the second body **152**.

The damping force variable valve assembly **140** includes a plunger **142** of which a moving distance is varied accord-

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ing to an amount of electric current applied to the solenoid **141**. On the other hand, the damping force variable valve assembly **140** includes the spool **144** that moves along a straight line while interlocking with the plunger **142** in a state of being disposed on the same axis as the plunger **142**. The spool **144** moves along the spool guide **145**. One end of the spool **144** comes into contact with the plunger **142**, and the other end of the spool **144** is elastically supported by a spool compression spring **146**. The spool compression spring **146** is supported by a plug **147** connected to the spool guide **145**. Therefore, the spool **144** moves forward by a pressurization of the plunger **142** and moves backward by a restoring force of the spool compression spring **146**.

Referring to FIG. 3, the spool **144** is provided by alternately forming large-diameter portions and small-diameter portions. That is, when viewed from above the drawing, a first large-diameter portion **144a**, a first small-diameter portion **144d**, a second large-diameter portion **144b**, a second small-diameter portion **144e**, and a third large-diameter portion **144c** are sequentially formed. As the spool **144** is moved by the solenoid **141**, the first small-diameter portion **144d** may communicate the first passage **145c** and the second passage **145d** formed in the spool guide **145**, and the second small-diameter portion **144e** may communicate the third passage **145e** and the second passage **145d** formed in the spool guide **145**.

According to the present invention, since the large-diameter portions are formed on both sides of the small-diameter portion, the pressure of the fluid is equally applied to both the large-diameter portions, and therefore, the position of the spool is not deviated by the pressure of the fluid.

That is, as indicated by an arrow of FIG. 3, for example, in a case where the first large-diameter portion **144a** is present, the pressure of the fluid is applied to only the top surface of the second large-diameter portion **144b** when the spool **144** moves and the first small-diameter portion **144d** communicates the first passage **145c** and the second passage **145d** of the spool guide **145**. Therefore, when viewing the spool **144** in the drawing, a downward force is applied to the spool **144**.

However, according to the present invention, since the first large-diameter portion **144a** is present, the pressure of the fluid is applied to both the bottom surface of the first large-diameter portion **144a** and the top surface of the second large-diameter portion **144b** when the spool **144** moves and the first small-diameter portion **144d** communicates the first passage **145c** and the second passage **145d** of the spool guide **145**. Therefore, a force for moving the spool **144** in one direction is not applied.

On the other hand, one end of the plunger **142** comes into contact with the spool **144**, and the other end of the plunger **142** is elastically supported by the spool compression spring **146**.

As the plunger **142** and the spool **144** are moved by the driving of the solenoid, a variable orifice is opened/closed or a passage area is adjusted by the interaction of the spool **144** and the spool guide **145**. Therefore, the opening/closing and/or the opening degree of a back pressure adjustment passage connected from the upstream side to the back pressure chamber **160** are/is controlled.

The present invention may be configured to generate a damping force even in a case where the moving speed of the working fluid is low (or ultra-low) because a low-speed control valve **170** is installed in parallel to the main valve **150**. The low-speed control valve **170** may include a low-speed disk-S **171** which is mounted on a low-speed control valve mounting surface of the valve body and in which a slit

is formed, and a low-speed disk **172** which can control an opening pressure or opening degree of the low-speed disk-S **171**. Although one low-speed disk-S **171** and one low-speed disk **172** are illustrated in the drawing, the number thereof can be changed when necessary upon their designs.

According to the present invention, when assembling the damping force variable valve assembly, a stepped portion is formed on an outer peripheral surface of an end portion of the inlet port **145a** of the spool guide **145**, and the low-speed control valve **170** is fitted to come into contact with the stepped portion. Then, the first body **151**, the second body **152**, and the main valve **150** are fitted. In this manner, the damping force variable valve assembly may be formed. Therefore, according to the present invention, it is unnecessary to use a nut and it is possible to prevent a change in the damping force of the low-speed valve according to a pressure caused by connection through the nut, as compared with the conventional assembling method in which the low-speed control valve **170** is installed in the valve body (that is, the first body **151**) and is fastened by a nut or the like.

Hereinafter, an operation state of the damping force variable valve assembly in a soft mode according to the present invention will be described in detail with reference to FIGS. **4** and **5**.

FIG. **4** illustrates an operation state when a flow rate of a working fluid is low (or ultra-low), and FIG. **5** illustrates an operation state when a flow rate of a working fluid is medium or high. As illustrated in FIGS. **4** and **5**, when the spool **144** is moved toward an opposite side of the inlet port **145a** by the operation of the solenoid **141**, the first passage **145c** and the second passage **145d** of the spool guide **145** communicate with each other. The working fluid is not supplied toward the back pressure chamber **160**. Therefore, the operation state becomes a soft mode state in which the damping force of the main valve is relatively lowered.

As illustrated in FIG. **4**, when the flow rate of the working fluid in the soft mode is low, the working fluid passing through the main passage, that is, the inlet port **145a**, the first inlet passage **145b**, the second inlet passage **151a**, and the third inlet passage **152a** flows toward the second passage **145d** of the spool guide **145** through the slit formed on the inner peripheral side of the disks included in the main valve **150**.

Then, the working fluid passing through the second passage **145d** flows toward the first passage **145c** through a space between the spool guide **145** and the first small-diameter portion **144d** of the spool.

Then, the working fluid passing through the first passage **145c** flows toward the first low-speed passage **152b** and the second low-speed passage **151b**, and a damping force is generated in a low flow rate section by the low-speed control valve **170**. As described above, according to the present invention, the damping force can be generated in a low-speed section, and a small vibration from a road surface can be effectively reduced to improve a ride comfort of a vehicle.

In addition, as illustrated in FIG. **5**, when the flow rate of the working fluid in the soft mode is medium or high, the working fluid passing through the main passage, that is, the inlet port **145a**, the first inlet passage **145b**, the second inlet passage **151a**, and the third inlet passage **152a** deforms and pushes the disks included in the main valve **150**, pass through the opened main valve **150**, and then flow toward the medium/high-speed passage **152c**. The working fluid moving toward the medium/high-speed passage **152c** immediately flows into the reservoir chamber **30** (that is, the low pressure chamber PL) within the shock absorber.

In the structure in which the low-speed control valve is connected in series to the main valve and the working fluid passes through the low-speed control valve and is then supplied to the main valve, the effect resulting from the low-speed control valve, that is, the effect that the damping force is generated even in the section where the moving speed of the working fluid is low, and the ride comfort can be improved during a fine vibration. However, the damping force characteristic of the main valve may be affected by the low-speed control valve. That is, since the working fluid needs to pass through the low-speed control valve even in the medium/high-speed section, the damping force characteristic of the main valve may be distorted.

However, in the structure of the present invention in which the low-speed control valve **170** is connected in parallel to the main valve **150**, it is possible to obtain the effect resulting from the low-speed control valve **170**, that is, the effect that improves fine vibration performance and achieve a rounded ride comfort by ensuring the degree of freedom of tuning in the low-speed section. In addition, since the damping force characteristic of the main valve **150** is not affected by the low-speed control valve **170**, the damping force characteristic of the main valve **150** is distorted. Consequently, the damping force non-interlocking is possible in the low-speed section and the medium/high-speed section, and the valve performance can be improved by ensuring the degree of freedom of tuning.

According to the structure of the present invention, the damping force scattering phenomenon can be improved because the passage of the working fluid flowing to the main valve **150**, that is, the main passage, is separated from the passage of the working fluid flowing to the low-speed control valve **170**, that is, the low-speed passage (first and second low-speed passages **152b** and **151b**).

In other words, the main passage and the low-speed passage form separate passages such that the main valve **150** and the low-speed control valve **170** can be installed in parallel. Therefore, according to the present invention, the working fluid supplied to the main valve **150** can be supplied to the main valve **150** without passing through the low-speed control valve **170**. In addition, the working fluid supplied to the low-speed control valve **170** can be supplied to the low-speed control valve **170** without passing through the main valve **150**.

As described above, the present invention can provide the damping force variable valve assembly having the valve structure for the low flow rate control, and the damping force variable shock absorber including the damping force variable valve assembly.

Therefore, the damping force variable valve assembly according to the present invention can improve a ride comfort of a vehicle by improve a damping force characteristic in a low-speed section (also including an ultra-low-speed section) to thereby effectively reduce a small frequent vibration from a road surface.

In addition, according to the present invention, since the low-speed control valve is installed not in series but in parallel to the solenoid main valve, the damping force of the medium/high-speed section obtained by the solenoid main valve is not affected by the installation of the low-speed control valve.

While the embodiments of the present invention have been described with reference to the specific embodiments, it will be apparent to those skilled in the art that various changes and modifications may be made without departing from the spirit and scope of the invention as defined in the following claims.

What is claimed is:

1. A damping force variable shock absorber for adjusting a damping force of the shock absorber, the shock absorber comprising:

a base shell in which a damping force variable valve assembly is attached to an outside of the base shell; an inner tube which is installed inside the base shell and in which a piston rod is installed movably in a length direction;

a piston valve which is connected to one end of the piston rod such that an inner space of the inner tube is partitioned into a rebound chamber and a compression chamber; and

a separator tube which partitions a space between the base shell and the inner tube into a low pressure chamber and a high pressure chamber,

wherein the damping force variable valve assembly comprises:

a solenoid which generates a magnetic force when an electric current is applied thereto;

a spool which is movable by the magnetic force of the solenoid;

a spool guide which surrounds the spool to guide a movement of the spool;

a valve body which is installed in the spool guide;

a main valve which is installed in a main passage formed in the valve body, and generates a damping force;

a back pressure chamber which is provided to have a back pressure to pressurize the main valve from the rear of the main valve;

a chamber forming body which is installed outside the valve body to form the back pressure chamber; and

a low-speed control valve which is installed in a low-speed passage formed in the valve body, and generates a damping force,

wherein the damping force of the shock absorber is variable between a hard mode in which the back pressure of the back pressure chamber is increased and a soft mode in which the back pressure of the back pressure chamber is decreased, when an inner passage within the damping force variable valve assembly is changed by interaction of the spool and the spool guide,

wherein the main passage and the low-speed passage form separate passages so that the main valve and the low-speed control valve are installed in parallel,

wherein in the soft mode, a working fluid supplied to the main valve does not pass through the low-speed control valve, and a working fluid supplied to the low-speed control valve does not pass through the main valve, and the low-speed control valve generates the damping force when a flow rate of a working fluid is low in the soft mode,

wherein the working fluid flows, from the high pressure chamber which is communicated with the rebound chamber and formed between the inner tube and the separator tube, through the main passage and the main valve, or through the low-speed passage and the low-speed control valve, directly to the low pressure chamber which is formed between the base shell and the separator tube, based on the flow rate of the working fluid in the soft mode,

wherein the spool comprises alternating large-diameter portions and small-diameter portions,

wherein the spool guide includes an inlet port, a first inlet passage, a first passage and a second passage,

wherein the valve body includes a second inlet passage and third inlet passage,

wherein in the soft mode, when the flow rate of the working fluid is low,

the working fluid passing through the main passage including the inlet port, the first inlet passage, the second inlet passage, and the third inlet passage flows toward the second passage through a slit formed on an inner peripheral side of disks included in the main valve,

the working fluid passing through the second passage flows toward the first passage through a space between the spool guide and a first small-diameter portion of the spool,

the working fluid passing through the first passage flows toward the low-speed passage,

the damping force is generated in a low flow rate section by the low-speed control valve, and

the working fluid passing through the low-speed passage flows toward the low pressure chamber.

2. The shock absorber according to claim 1, wherein the valve body is formed by sintering, and the chamber forming body is formed by press processing.

3. The shock absorber according to claim 1, wherein the large-diameter portions are formed on both sides of each small-diameter portion so that a pressure of a working fluid passing through the small-diameter portion is equally applied to the large-diameter portions formed on both sides of the each small-diameter portion.

4. The shock absorber according to claim 1, wherein a stepped portion coming into contact with the low-speed control valve is formed on an outer peripheral surface of the inlet port of the spool guide, and the low-speed control valve is assembled by interposing between the stepped portion and the valve body fitted into the spool.

5. A damping force variable shock absorber for adjusting a damping force of the shock absorber, the damping force variable shock absorber comprising:

a base shell in which a damping force variable valve assembly is attached to an outside of the base shell;

an inner tube which is installed inside the base shell and in which a piston rod is installed movably in a length direction;

a piston valve which is connected to one end of the piston rod such that an inner space of the inner tube is partitioned into a rebound chamber and a compression chamber; and

a separator tube which partitions a space between the base shell and the inner tube into a low pressure chamber and a high pressure chamber,

wherein the damping force variable valve assembly comprises:

a spool which is movable by a magnetic force of a solenoid;

a spool guide which surrounds the spool to guide a movement of the spool;

a main valve which is installed to cover a main passage formed in a valve body installed in the spool guide and generates a damping force; and

a low-speed control valve which is installed to cover a low-speed passage formed in the valve body and generates a damping force,

wherein the damping force of the shock absorber is variable between a hard mode in which a back pressure of a back pressure chamber installed at the rear of the main valve is increased and a soft mode in which the back pressure of the back pressure chamber is

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decreased, as an inner passage within the damping force variable valve assembly is changed by interaction of the spool and the spool guide,

wherein the main passage and the low-speed passage form separate passages so that the main valve and the low-speed control valve are installed in parallel, 5

wherein in the soft mode, a working fluid supplied to the main valve does not pass through the low-speed control valve, and a working fluid supplied to the low-speed control valve does not pass through the main valve, and the low-speed control valve generates the damping force when a flow rate of a working fluid is low in the soft mode, 10

wherein the working fluid flows, from the high pressure chamber which is communicated with the rebound chamber and formed between the inner tube and the separator tube, through the main passage and the main valve, or through the low-speed passage and the low-speed control valve, directly to the low pressure chamber which is formed between the base shell and the separator tube, based on the flow rate of the working fluid in the soft mode, 15

wherein the spool comprises alternating large-diameter portions and small-diameter portions,

wherein the spool guide includes an inlet port, a first inlet passage, a first passage and a second passage, 20

wherein the valve body includes a second inlet passage and third inlet passage, 25

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wherein in the soft mode, when the flow rate of the working fluid is low,

the working fluid passing through the main passage including the inlet port, the first inlet passage, the second inlet passage, and the third inlet passage flows toward the second passage through a slit formed on an inner peripheral side of disks included in the main valve,

the working fluid passing through the second passage flows toward the first passage through a space between the spool guide and a first small-diameter portion of the spool,

the working fluid passing through the first passage flows toward the low-speed passage,

the damping force is generated in a low flow rate section by the low-speed control valve, and

the working fluid passing through the low-speed passage flows toward the low pressure chamber.

6. The shock absorber according to claim 1, wherein the spool is free from including a passage traversing an extension direction of the main passage in the at least one small diameter portion.

7. The damping force variable shock absorber according to claim 5, wherein the spool is free from including a passage traversing an extension direction of the main passage in the at least one small diameter portion.

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